**Quotation for Department of Water & Environmental Regulation**

**2019**

**Assessing the implications of revising threshold levels on wetland and bushland values for sites in Statement 819 – Gnangara Groundwater Resources**

**Submitted by Ray Froend and Pierre Horwitz**

**Centre for Ecosystem Management**

**Edith Cowan University**

# **Project Context**

Excerpts from the DWER Request are included below as context for this quotation.

The Department of Water and Environmental Regulation (DWER) has environmental conditions set on its management of Gnangara groundwater resources, specified in Ministerial Statement 819. The Statement specifies minimum water level criteria or thresholds that the department must meet at staff gauges and/or monitoring bores at 14 wetlands and 16 bushland sites in the area covered by the Gnangara groundwater allocation plan, north of Perth (Figure 1).

Due to groundwater declines, the department has been unable to meet the criteria levels at approximately half of the sites in recent years. It is in the process of preparing a draft Gnangara groundwater allocation plan to be released for public comment in mid-2019, which if implemented, will reduce groundwater abstraction in the plan area by a total of up to 44 GL/yr in 2028. However, projected modelling shows that despite reduced abstraction – and with a continued drying climate – the department will still not be able to achieve the current ‘absolute minimum’ levels at around half of the criteria sites and compliance rates will remain very similar to current rates.

For these sites, the department proposes to alter the water level criteria, and has requested a review of the implementation conditions in Statement 819. The department has developed a new set of water level criteria based on what groundwater modelling has indicated can be met through reduced abstraction and (in some areas) planned land use changes.

Groundwater modelling indicates that several East Wanneroo wetlands (e.g. Lakes Mariginiup, Jandabup, Joondalup and Goollelal) could experience a substantial increase in future water levels through increased water recharge from urban development and a decrease in abstraction as agricultural water licenses expire. Although maximum water level criteria are of little relevance due to ongoing water level declines, a review of the validity of the original maximum water level criteria at these wetlands is necessary to support future decisions around groundwater management.

**Objective 1)**

To assess the proposed 2030 water level thresholds against the original listed site management objectives and values to determine:

a) which of the original stated objectives can/can’t be achieved and;

b) what values can/can’t be protected.

The thresholds – if implemented – will not apply until 2030 as this is the end of the planning period for the new Gnangara plan and is after the 2028 reductions to abstraction have begun to have an effect on water levels.

**Objective 2)**

To review, and if necessary, suggest revisions to the new (proposed) management objectives to reflect what is achievable under the proposed changes to the minimum thresholds.

**Objective 3)**

To consider the model projections for the aforementioned four East Wanneroo wetlands identified and assess whether the WAWA (1995) maximum water level criteria are still valid (meet the proposed management objectives or whether a) an alternative value should be set, or b) further review is required to set a more appropriate maximum threshold.

**Objective 4)**

To establish a minimum (and, if necessary a maximum) water level threshold at the staff gauge and bore GLP\_EC, based on maintaining the lake’s ecological and social values. Modelling projects that water levels will rise in the Lake Gwelup area by around 0.6 m.

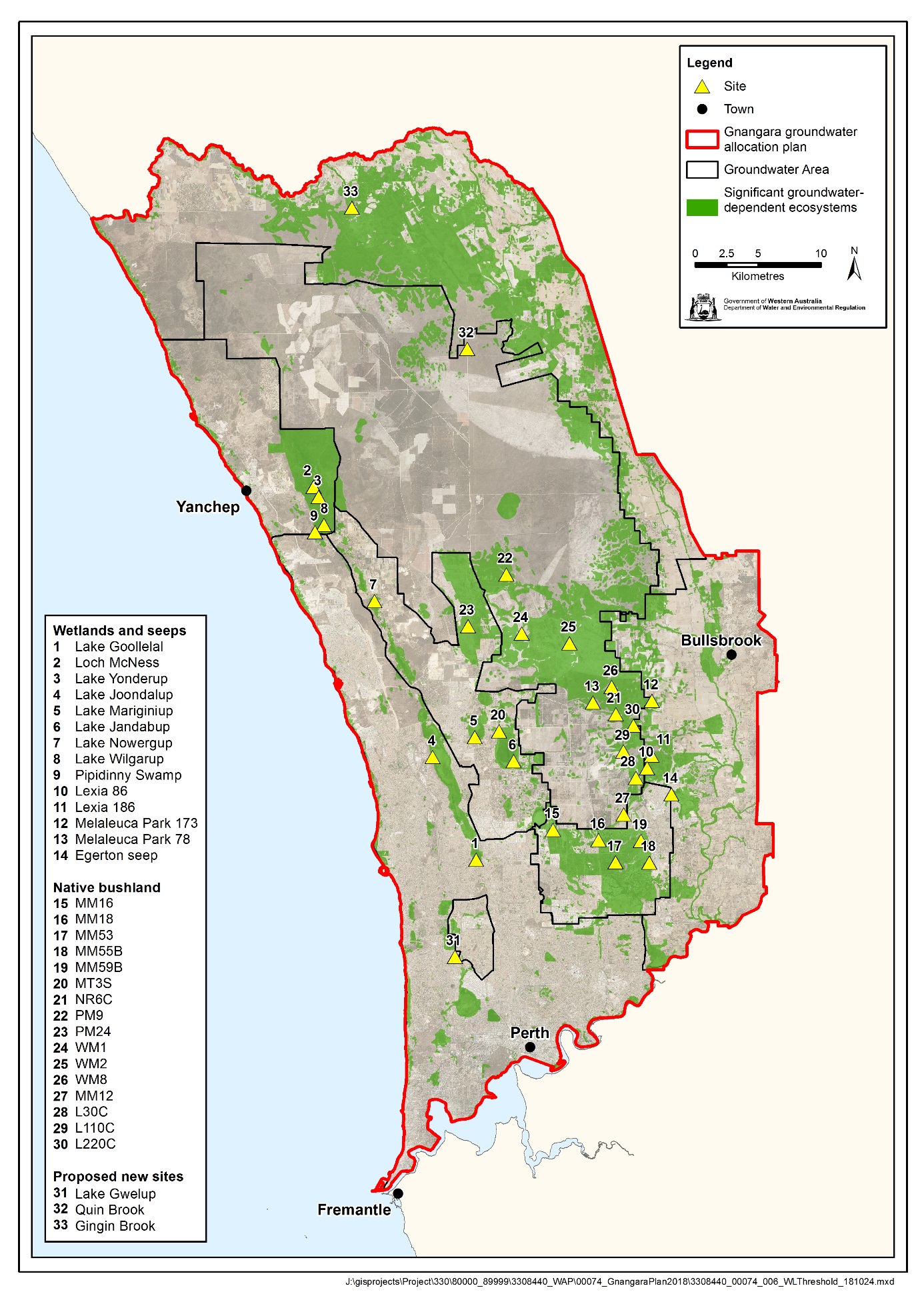


Figure 1. Location of Ministerial criteria sites and proposed new sites, including Lake Gwelup.

# **Approach and Deliverables**

The Department of Water and Environmental Regulation requires a contractor to conduct a review of the minimum water criteria required at sites where modelling has cited that existing criteria, even under proposed reductions in abstraction, are unable to be met. Edith Cowan University’s Centre for Ecosystem Management (CEM) will undertake Tasks 1-5 as follows.

## **Tasks 1 – 3**

Task 1: For sites listed in Table 1 (refer Appendix 1), CEM will assess what effect altering absolute minimum threshold water levels may have on:

* 1. achieving the original stated site management objectives in Table 1
  2. the original stated site values in Table 1, and

c) where these are different from 1b), the current values as described in recent monitoring reports.

(n.b. A description of the proposed new threshold levels for each site is described in Table 2. Note that Lake Gwelup is not included in Tasks 1 to 4, but is included in Task 5.)

CEM will base this assessment on whether or not the new threshold levels will meet the water requirements for these specific ecological values:

* + species composition
  + key, priority or threatened species
  + existing ecohydrological states

Task 2: For each site, CEM will assess the significance of the impacts/changes found in Task 1 (taking into account guidance from the Environmental Protection Authority on the definition of “significant’ effects (EPA, 2018b)).

Task 3: For each site, CEM will assess whether the proposed new minimum threshold water levels (described in Table 2, Appendix 1) will meet the proposed management objectives (also described in Table 2). Where the proposed thresholds and proposed management objectives do not align, CEM will recommend amendments to the management objectives.

## **Task 4**

For the wetlands likely to be affected by planned land use changes in East Wanneroo (refer Appendix 1, Table 3), CEM will assess whether the original maximum water level criteria stated in WAWA (1995):

* + are appropriate to meet the proposed management objectives in Table 2, and protect site ecological and social values, or
  + require revision.

If the maximum thresholds require revision, CEM will recommend an appropriate maximum threshold (including justification).

## **Task 5**

CEM will:

a) Review the proposed management objectives for Lake Gwelup (see Table 2) and consider the ecological, social and cultural values of the lake in this review.

1. Propose a minimum water level threshold, and if required, a maximum threshold, at bore GLP\_EC to meet the management objectives developed in 5a).

**Personnel**

**Professor Ray Froend**

Centre for Ecosystem Management

School of Science

Edith Cowan University

Joondalup, Western Australia.

Ray’s research has a focus on plant ecology and related hydrology and he has maintained a high profile in this specific research area for over 2 decades. Ray has a national and international profile in research on groundwater dependent ecosystem response to altered hydrological regimes and particularly in phreatophyte ecology. This profile has resulted in numerous appointments to advisory and review panels, and his research continues to be aligned with strategic research priorities nationally and internationally with increasing government and industry focus on water resource management, global change and conservation.

**Professor Pierre Horwitz**

Centre for Ecosystem Management

School of Science,

Edith Cowan University

Joondalup, Western Australia.

Pierre’s research and teaching have included an ecosystems approach to the relationships between biodiversity, culture and human health and well-being, with a particular interest in water and wetlands in Australia. In particular he has had the fortune of monitoring wetlands of the Gnangara groundwater system continuously since 1996 and getting to know far southwestern peatlands and heathlands in Nyoongar boodja, as well as salt lake systems of northwestern Australia. Pierre has held an appointment for the Ramsar International Convention on Wetlands as Theme Coordinator for Wetlands and Health on its Scientific and Technical Review Panel 2009-2015.

**Dr Chris Kavazos**

Centre for…

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University of New South Wales

Sydney, NSW

Chris completed his PhD on the microbial ecology of Lake MacLeod in 2016. He has since been undertaking post-doctoral research work in collaboration with researchers from the University of New South Wales and the University of Newcastle on the microbiomes of fish, corals and clams in the Great Barrier Reef. Chris has contributed research papers to international journals with his work concentrated on testing ecological theories in natural communities. This publication record demonstrates Chris’s strong skills in community ecology and ecological statistics.

**Grant Buller**

Centre for Ecosystem Management

School of Science,

Edith Cowan University

Joondalup, Western Australia.

Grant has worked as a Research Assistant with CEM since July 2015. His role has primarily involved conducting the fringing wetland vegetation monitoring component of the Environmental Investigations and Monitoring of the Gnangara and Jandakot Groundwater Mounds, including undertaking spring field surveys, data analysis, and preparation and submission of reports to DWER.

# **Data and information**

The Centre for Ecosystem Management requires – upon request – the relevant background information for the assessment, including monitoring reports, monitoring bore and staff gauge locations and hydrographs.

# **Time frame**

CEM will complete the proposed work for Tasks 1-3 by 18th September 2019.

**Project payment schedule**

|  |  |  |  |
| --- | --- | --- | --- |
| **Milestone** | **Description** | **Due** | **Payment Schedule** |
| 1 | Completion of and submission of a brief progress report on Tasks 1 to 3 (digital format) to the Project Manager. | 17 July 2019 | 40% of contract value |
| 2 | Submission of a draft final report (digital format – Microsoft Word version) to the Project Manager. | 30 August 2019 | 40% of contract value |
| 3 | Following submission of an acceptable final report, incorporating any relevant changes to the draft report requested by DWER.  The final report should be submitted to the Project Manager in digital format (pdf version). All data should also be provided in digital format (Microsoft Excel version). | 18 September | 20% of contract value |

# **Cost**



**Total for Tasks 1-3: $32254.12 excl. GST complete by 18th September**

**Total for Tasks 1-5: $38582.36 excl. GST completion date to be negotiated.**

# **References**

Environmental Protection Authority 2018a, *Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans*, April 2018, EPA, Western Australia.

Environmental Protection Authority 2018b, *Statement of Environmental Principles, Factors and Objectives*, EPA, Western Australia.

Water and Rivers Commission 1997, *East Gnangara Environmental Water Provisions Plan,* Public Environmental Review, WRC, Perth.

Water Authority of Western Australia 1995, *Review of Proposed Changes to Environmental Conditions – Gnangara Mound Groundwater Resources (Section 46)*, WAWA, Perth.

# **Appendix 1**

Table 1: Current Ministerial criteria and management objectives for relevant sites.

| **Site name** | **Site values**  **(WAWA,1995 or WRC, 1997)** | **Site management objectives**  **(WAWA,1995 or WRC, 1997)** | **Bore or staff gauge where Ministerial criteria/target/ threshold are measured** | **Absolute minimum (or minimum peak) Ministerial criteria**  **mAHD** | **Preferred minimum (or minimum peak) Ministerial criteria**  **mAHD** | **Compliance and ecological trends** |
| --- | --- | --- | --- | --- | --- | --- |
| Lake Goollelal | (WAWA, 1995)   * Waterbird habitat and drought refuge * Supports good populations of native fish species, Swan River goby (*Pseudogobius olorum*) and the western pygmy perch (*Edelia vittata*) | (WAWA, 1995)   * Conservation and public enjoyment of natural and modified landscapes * Protect and if possible enhance, fringing wetland vegetation including woodland and sedge vegetation * Maintain permanent, deep water for waterbird habitat and as a drought refuge * Maintain permanent water for fish and other dependent species * Maintain the landscape amenity values of the wetland | 6162517  (staff 459) | 26.0 | 26.2 | Lake Goollelal has not breached water level criteria. Maximum and minimum water levels have not undergone significant changes in the last decade. Water levels have been slightly higher in the last three decades than they were in the 1970s and 1980s. Minimum water levels have generally been increasing since 2011, apart from a dip in 2016, when average water levels across Gnangara were at their lowest. Vegetation monitoring was initiated in 1997. The vegetation transect was last monitored in 2014, and prior to that, in 2011. Between 2011 and 2014 canopy condition declined 6% and exotic plant species increased significantly. Since monitoring began, species composition at the transect has changed markedly. Macroinvertebrate assemblages changed after 2006, but two recent sampling results may indicate a reversal of this trend possibly due to higher water levels. The chloride:sulphate ratio has improved since 2017. |
| Loch McNess | (WAWA, 1995)   * Undisturbed wetland * Unusual hydrologic regime * Rich aquatic fauna * Vegetation largely intact, provides a range of habitat types * Supports good populations of water birds and acts as a drought refuge * Excellent water quality | (WAWA, 1995)   * Maintain the environmental quality of the lake * Maintain North Loch NcNess’ pristine state * Continue to use south Loch McNess for low key recreation * Maintain east Loch McNess in a natural state, to restore, where possible, natural flow * Maintain the existing hydrological regime | 6162564  (staff 8754) | 6.95 |  | Loch McNess has been non-compliant with minimum water level criterion since 2002-03. Previously stable water levels at the lake appear to have reached a ‘tipping point’ in summer 2006/07 and declined rapidly since, but have been relatively stable since 2016. Wetland vegetation has been monitored since 2004. Water level declines, fire (2004, 2009) and land use impacts have led to the disappearance of *Baumea* from the transect, and increase in exotic species. Macroinvertebrate assemblages have changed over the monitoring period and are no longer typical of the lake. This is a direct result of low water levels. Nutrient concentrations, particularly phosphorus, have been increasing at the lake. |
| Lake Yonderup | (WAWA, 1995)   * High ecological values due to undisturbed nature * Rich invertebrate fauna * Excellent water quality * Undisturbed hydrologic regime and lack of seasonal variation | (WAWA, 1995)   * Maintain the environmental quality of the lake * Maintain the existing hydrological regime | 6162565 (staff 8780) | 5.9 |  | Lake Yonderup has been non-compliant with minimum water level criterion since 2007-08. Previously stable water levels at the lake appear to have reached a ‘tipping point’ in summer 2010/11 and declined rapidly since, but have been relatively stable since 2016. Wetland vegetation has been monitored since 1997 at one transect and since 2007 at second, northern transect. Fire affected the lake’s vegetation in 2005. The range of *M. raphiophylla,* *B. ilicifolia*, and *Baumea* sedges on the transect has reduced at the wetter end. Macroinvertebrate richness in 2017 & 2018 was the lowest on record. Yonderup has retained a characteristic assemblage but habitats have been lost or are being degraded as a direct result of low water levels. Assemblages are showing change. Nitrogen levels were the equal highest recorded in 2018, and there is a risk of acidification should water levels continue to decline. |
| Lake Joondalup | (WAWA, 1995)   * Waterbird habitat and drought refuge * Diverse range of macrophytes | (WAWA, 1995)   * Conservation and public enjoyment of natural and modified landscapes * Conserve existing wetland vegetation, including sedge beds, fringing woodland and aquatic macrophytes * Maintain and if possible, enhance the aquatic fauna of the lake * In conjunction with Lake Goollelal, to support the full range of habitats for avian fauna * Ensure the landscape and amenity values of the lake are maintained, except under very low rainfall climatic conditions | 6162572 (staff 8281)  [61610661 (bore 8281) | 15.8 | 16.2 | Lake Joondalup has been compliant with absolute minimum water levels but not compliant with the preferred minimum ‘2 in 6’ criteria since the 1990s. Maximum and minimum levels were fairly consistent since the mid-1990s but have generally been increasing since 2012 apart from a dip in 2016, when average water levels across Gnangara were at their lowest. Vegetation monitoring was initiated in 1995. There has been some improvement in canopy condition 1995-2012 at the northern transect, and little change at the southern transect. Tree abundance has slightly decreased at both transects. Nutrient levels have been a concern but in the 2018 sampling total phosphorus dropped considerably. Acidity levels were of concern in 2016 but pH has since been improving. Macroinvertebrate sampling in 2018 showed that insects were almost completely absent from sampling. The reason for this is unclear but is not attributable to low water levels. |
| Lake Mariginiup | (WAWA, 1995)   * Rich aquatic fauna (Swan River Goby, *Pseudogobius olorum*) * Wading bird habitat * Good water quality | (WAWA, 1995)   * Conservation of flora and fauna * Maintenance of the existing areas of fringing sedge vegetation * maintain invertebrate diversity through some lake bed drying in summer * Maintain and if possible, enhance fringing woodland vegetation | 6162577 (staff 1943)  61610685 (bore MS10) | 41.5 (minimum peak) | 42.1 (preferred min peak) | Lake Mariginiup has been non-compliant with the absolute minimum spring peak criterion in seven of the last ten years. Spring peak water levels have shown a generally increasing trend over the last few years, due to urbanisation in East Wanneroo, but prior to that had been declining since the 1990s. Low water levels have caused acidification at the lake, but pH levels are slowly increasing and macroinvertebrate richness is still relatively high and is improving. Nutrient levels are increasing at the lake. Vegetation monitoring was first conducted in 1996 and the most recent monitoring occurred in 2018. The transect has low native species richness, and overall the vegetation is in poor condition due to a combination of low water levels, fire and insect attack. |
| Lake Jandabup | (WAWA, 1995)   * Most diverse sedge and macrophyte vegetation of all Bassendean dune wetlands, including unusual species * Supports wide range of waterbirds, especially waders * Extremely good water quality with low nutrients | (WAWA, 1995)   * Conservation of flora and fauna * Maintenance of the current extent of wading bird habitat * No expansion in the areas of sedge vegetation, but maintenance of existing areas * Removal of mosquito fish from the lake * Maintenance of high species richness of aquatic macroinvertebrates, macrophytes and sedge vegetation | 6162578 (staff 1944) | 44.2  (minimum peak) | 44.7 (preferred peak) | Lake Jandabup is artificially maintained by the Water Corporation so water levels have been reasonably stable for the last decade, although absolute minimum levels have been below the criterion most years. Low water levels caused acidification at the lake in the late 1990s but the lake recovered when the artificial maintenance regime was modified to keep the sediments wet. However, acidification of the lake remains a risk. Lake Jandabup has always had low nutrient levels, but recent results show an increasing trend. Macroinvertebrate richness has historically been high, but recent results show changes in assemblages and more monitoring is needed to ascertain whether this is actually occurring or whether it’s a factor of fewer sites being sampled than previously.  The Jandabup South vegetation transect was first monitored in 1996 and most recently in 2017-18. Vegetation at the transect is in good health overall with a low number of exotic species. |
| 6162578 (staff 1944) | 44.3 (absolute minimum) |  |
| Lake Nowergup | (WAWA, 1995)   * As a permanent deep-water wetland acts as a major drought refuge for waterbirds * Supports dependent invertebrates and fish species (one native, Swan River Goby (*Pseudogobius olorum*); and one exotic, Mosquito fish (*Gambusia holbrooki*) * Large areas of sedges minimize impact of nutrient enrichment on aquatic fauna | (WAWA, 1995)   * Wildlife and conservation, scientific study and preservation of features of archaeological, historic or scientific interest * Maintain the existing areas of fringing sedge vegetation * Maintain deep, permanent water as a bird habitat and drought refuge and to protect aquatic invertebrates and fish dependent on permanent water * Maintain the existing extent of *Baumea* fringe between *Typha* stands and the fringing woodland * Provide some area of wading bird habitat at the end of summer, although it is recognized that this is limited by the shape of the wetland. | 6162567 (staff 8756) for Ministerial criteria | 16.8 (minimum peak) | 17.0 (preferred peak) | Lake Nowergup is artificially maintained by the department. It has been non-compliant with the absolute minimum peak water level criterion for most of the last two decades. Surface water levels at the lake have declined by around two metres since monitoring began in the early 1970s. The lake used to be one of the deepest on the Swan Coastal Plain. Water level declines have reduced the size of the lake and altered the fringing vegetation. Macroinvertebrate richness has reduced over the monitoring period, mainly because of the loss of fringing macrophyte habitats. Nutrient concentrations are increasing and levels are cause for concern.  Two vegetation transects were established at Lake Nowergup in 1996 and the southern transect was most recently monitored in 2018. Vegetation in both transects is in poor condition, particularly the southern transect. In 2000 and 2002 there were a large number of deaths of fringing tree species when water levels exceeded a threshold. There is a high abundance of exotic species in both transects. |
|  |
| Lake Wilgarup | (WAWA, 1995)   * One of few remaining undisturbed wetlands within the region * Rich and unusual vegetation (dense monospecific stands of sedges) * Likely to support diverse fauna | (WAWA, 1995)   * Maintain the environmental quality of Lake Wilgarup * Maintain the existing extent and variety of wetland vegetation | 61618500 (Wilgarup Lake bore) | 4.5  5.65 (spring peak) | 4.8  6.1  (spring peak) | Lake Wigarup has been non-compliant with absolute minimum water level criteria for almost two decades. It last had water at the staff gauge in 1998 and the vegetation existing at the wetland has completely changed as a result of water level declines and a fire in 2005. It is no longer sedge-dominated and no *Banksia littoralis* have existed at the transect since the fire. Condition of *M. rhaphiophylla* remains very poor. Water quality and macroinvertebrates are no longer monitored at Lake Wilgarup as there is no longer any surface water present. The 2005 fire eroded the organic soils and left the wetland prone to acidification. Low pH levels were apparent when the wetland was last sampled in the mid-2000s. |
| Pipidinny Swamp |  | *1b) Improve health*  Improve groundwater levels to:   * increase area of permanent deep water habitat for fauna * maintain fringing vegetation to support a range of habitat types for macroinvertebrates. | 6162624 (staff)  61611872 (bore PIP\_C) | 1.6 | 1.0 | Pipidinny Swamp has been non-compliant with absolute minimum and absolute minimum peak water level criteria for at least the last decade, though compliance with the absolute minimum was not possible to confirm in some years prior to 2010 as the staff gauge could not measure levels below 2.0m AHD. In 2010 the staff gauge was improved and lower water levels could be read. No vegetation monitoring occurs at Pipidinny Swamp, but surrounding vegetation was significantly affected by a fire in 2005. Macroinvertebrate and water quality monitoring occurred in the 2000s but ceased in 2011 as the wetland was atypical and had little water. |
| Lexia 186\* | (WRC, 1997)   * Undisturbed by typical impacts * Supports diverse vegetation * Significant fauna habitat | (WRC, 1997)   * Conserve ecological values * Protect vegetation assemblages in and fringing the wetland * Protect invertebrate communities dependent on the wetland | 61613214 (bore GNM15) | 47.2 | 47.5 | Lexia 186 has only been compliant with the absolute minimum water level criterion once in the last two decades. Macroinvertebrates and water quality monitoring occurred episodically in the early 2000s, but as the wetland was highly seasonal and water levels have since declined and surface water is no longer present, monitoring has ceased. Declining groundwater levels have been linked to the possible disappearance of two frog species from Lexia 186, and acidification is also a concern. Vegetation monitoring commenced in 1997 and overall there has been a slight decline in mean canopy health of all species combined. Native species’ richness has increased overall since 1998, and presence of weed species has remained low over the monitoring period. |
| Melaleuca Park 173 | (WRC, 1997)   * Unique hydrology * High vertebrate and macroinvertebrate species richness * Contains most northern population of black stripe minnow (*Galaxiella nigrostriata*) | (WRC, 1997)   * Maintain wildlife and landscape values of the wetlands * Maintain the existing areas of wetland and stream vegetation they support * To protect invertebrate communities dependent on the wetland and stream * To protect the fish species, *Galaxiella nigrostriata* | 61613213 (bore GNM14) | 50.2 |  | Melaleuca Park 173 has consistently been non-compliant with absolute minimum water level criteria. Water level declines have resulted in the death of fringing vegetation, degrading macroinvertebrate habitats. The wetland is now almost dry in summer, and it’s assumed that the local population of the black-striped minnow is now extinct. Peak water levels have improved since 2016, and in spring 2018 levels were high enough to allow some outflow in the north-eastern drainage channel. The wetland is naturally acidic (pH 3.4 to 5.1) due to the organics in the soil. It is the only wetland to show a positive relationship between water levels and invertebrate richness.  Vegetation has been monitored at the wetland since 1997, and it has experienced the largest decrease in mean canopy condition of all the monitored wetlands. Total cover-abundance of exotic species remains low, but has increased since 1997. *Pericalymma ellipticum* has disappeared from the transect,numbers of *Baumea articulata*  have declined significantly, and tree health has also declined as the transect has dried. Higher water levels over the last few years has improved tree health and canopy condition and *B. articulata* has reappeared for the first time since 2014. |
| Melaleuca Park 78 | (WRC, 1997)   * Supports wetland vegetation | (WRC, 1997)   * Maintain wildlife and landscape values of the wetlands * Maintain the existing areas of wetlands and wetland vegetation | 61613231 (bore GNM31) | 65.1 | 65.4 | Melaleuca Park 78 has been non-compliant with absolute minimum water level criteria since 2012. Water levels at the site were on a declining trend from the beginning of monitoring in 1999 until 2016, dropping by around 1.3m, but have recovered slightly in the last three years after improved rainfall in 2017 and 2018. The vegetation transect has been monitored at the wetland since 1997 and was last monitored in 2018. In 2006, the transect was heavily affected by a fire, but has since made some recovery. *Baumea articulata* has now disappeared from the transect, mean canopy condition has declined by 16% and exotic species’ cover-abundance has increased since the baseline year. |
| MM59B Whiteman Park East | (WAWA, 1995)   * Selected to represent water levels over area of undisturbed phreatophytic vegetation * Banksia woodland <8m depth to groundwater | (WAWA, 1995)   * To protect terrestrial vegetation | 61611025 (bore MM59B) | 36.3 |  | Water levels at MM59B have been monitored since 1978 and have declined 1.0 – 1.5m over this time. Levels have exceeded the absolute minimum criteria level in most years since 1991. After reasonable rainfall in 2017 and 2018, minimum water levels have been on an increasing trend since 2016 and are currently similar to what they were in the mid-2000s.  See MM53 for information about vegetation trends in Whiteman Park. |
| PM9 Pinjar North | (WAWA, 1995)   * Selected to represent water levels over area of undisturbed phreatophytic vegetation | (WAWA, 1995)   * Protect terrestrial vegetation | 61610804 (bore PM9) | 56.3 | - | Water levels at PM9 have been monitored since 1976 and have fallen approx. 7 metres over this time. It is assumed that vegetation at this site is now no longer able to access groundwater. The nearest vegetation monitoring transect is ‘P50’, located near the Water Corporation’s P50 production bore east of Lake Pinjar, approximately 2.2 km away to the south-west. The P50 transect has been subjected to different influences over the years, including (previous) pumping of the P50 production bore and widespread deaths of vegetation following a succession of high temperatures in the early 1990s, and several fires. There has been an increase in the frequency and cover of species that prefer ‘broad’ site conditions, and an increase in the relative proportion of cover from introduced species. There is a consistent decline on the transect in species preferring excessive wetness. |
| WM1 Pinjar | (WAWA, 1995)   * Selected to represent water levels over area of undisturbed phreatophytic vegetation * Banksia woodland <8m depth to groundwater | (WAWA, 1995)   * To protect terrestrial vegetation | 61610833 (bore WM1) | 55.7 |  | Water levels at WM1 have been monitored since 1975 and have declined 3 to 4 metres over this period. Water levels showed an ongoing declining trend until around 2013 when they appeared to stabilise and have been trending upwards since 2016.  The nearest vegetation monitoring transects are ‘P50’, described above and located nearly 5km to the north-west, and ‘Neaves’, located almost the same distance away to the south-east. The Neaves transect was established in 1966. Like the P50 transect, the Neaves transect shows general decline in species tolerating excessive wetness and an overall increase in the range of species tolerating ‘broad’ site conditions. The transect has been regularly affected by fire, most recently the year before the 2017 monitoring, and the burnt areas were still re-establishing at the time of monitoring. The 2017 monitoring showed a decrease in cover of exotic species. |
| WM2 Melaleuca Park North | (WAWA, 1995)   * Selected to represent water levels over area of undisturbed phreatophytic vegetation * Banksia woodland <8m depth to groundwater | (WAWA, 1995)   * To protect terrestrial vegetation | 61610908 (bore WM2) | 66.5 |  | Water levels at WM2 have been monitored since 1975 and have declined 2 to 3 metres over this period. Water levels have fluctuated over the monitoring period, declining between 1975 and 1991, rising slightly and then declining again between 1997 and 2013. Water levels have been trending upwards since 2015.  The nearest vegetation monitoring transect is ‘Neaves’, located 3.5 km away to the south-west. Monitoring results for Neaves are described above for WM1. |
| WM8 Melaleuca Park | (WAWA, 1995)   * Selected to represent water levels over area of undisturbed phreatophytic vegetation * Banksia woodland <8m depth to groundwater | (WAWA, 1995)   * To protect terrestrial vegetation | 61610983 (bore WM8) | 64.8 |  | The nearest vegetation monitoring is ‘Melaleuca’, located almost 2 km away to the south-west in the southern fringes of the Melaleuca Park conservation area. The Melaleuca transect was established in 1996 and most recently monitored in 2014. Over that period there has been a slight increase in the range of species on the transect, and a decline in species preferring wet sites. There has been an increase in the cover of most species groupings. Most of the major tree species on the transect have shown an overall decline in health over the monitoring period. |
| Lake Gwelup |  | *1b) Maintain health*  To maintain permanent water for fauna habitat and for visual amenity, to maintain fringing vegetation. | 61610032 (bore 8525)  6162504 (staff 465) |  |  | Not currently a Ministerial criteria site, but DWER is proposing that it should be added as a new site in the EPA’s review.  Lake water levels were first monitored in 1960, but regular monitoring has occurred between 1967 and 1988, and from 1999 until the present. Lake levels in the 1970s and 1980s were 1m to 2m higher than in the 2000s. They have risen again since 2013 following a reduction in nearby public water supply abstraction, and levels are currently similar to levels in the 1980s. Nearby bore 61610032 has been monitored since 1972. Water levels at the bore have declined by around 4 metres since the start of monitoring. Levels have been reasonably stable since the early 2000s and have trended slightly upwards since 2011.  A vegetation monitoring transect was established at Lake Gwelup in 2013 and it was last monitored in 2017. The higher water levels at the lake has inundated around half of the transect, and is probably the reason for the large drop in the cover-abundance of exotic species, and the low species similarity scores to the previous survey. The remainder of the transect is still dominated by exotic species, a reflection of its urban setting. The native tree species on the transect are mostly in good to excellent health. |

Table 2: Proposed site management objectives and 2030 threshold water levels.

| **Site name** | **Site management objectives** | **Bore or staff gauge where Ministerial criteria/target/ threshold are measured** | **Current absolute minimum (or minimum peak) Ministerial criteria**  **mAHD** | **2030 threshold level**  **mAHD** | **Notes i** |
| --- | --- | --- | --- | --- | --- |
| Lake Goollelal | *1b) Maintain health*  Maintain groundwater levels to:   * maintain permanent surface water for fauna habitat and visual amenity * maintain fringing vegetation * minimise risk of acidification and nuisance midge proliferation. | 6162517  (staff 459) | 26.0 | 26.4 | Monitoring shows that managing water levels to the existing minimum criterion will not meet site management objectives and that the criterion should be raised to reduce risk of acidification and nuisance midge proliferation. Current levels are above the proposed threshold and modelling projects the threshold level can be met at 2030.  **Details of proposed change to Ministerial criteria:**. Beyond 2028, once the abstraction reductions have been implemented, adopt a threshold level of 26.4 (0.4 m higher than the existing minimum criterion). |
| Loch McNess | *1b) Improve health*  Improve groundwater levels to:   * increase surface area of permanent water for fauna habitat and visual amenity * maintain healthy, intact fringing vegetation * maintain diverse habitat types and excellent water quality. | 6162564  (staff 8754) for Ministerial criteria | 6.95 | 6.2 | Staff gauge is not able to measure low water levels in current location and needs to be shifted to a deeper part of the lake. In the interim, YN5 is being used as the criteria site until the corresponding threshold levels can be confirmed at the new (translocated) staff gauge.  Modelling projects only small rises are possible in Yanchep National Park under the planned abstraction reductions – not enough to meet existing Ministerial criteria. Changes to local abstraction e.g. within the Park itself may be able to improve water level outcomes further than current modelling projects, and will require more investigation within the life of the plan. It may be possible to achieve a higher threshold as a result.  **Details of proposed change to Ministerial criteria:** Beyond 2028, adopt a threshold level of 8.0 mAHD at YN5.  Based on the past relationship between water levels at the staff gauge and YN5, achieving a minimum level of 8.0 mAHD at YN5 should give a lake level threshold of 6.2 mAHD (0.75 m below the existing criterion). |
| 61612104 (bore YN5) for trigger and threshold levels |  | 8.0 |
| Lake Yonderup | *1b) Improve health*  Improve groundwater levels to:   * increase surface area of permanent water for fauna habitat * maintain intact, undisturbed fringing vegetation * maintain diverse habitat types and excellent water quality. | 6162565 (staff 8780) | 5.9 | 5.7 | Modelling projects only small rises are possible in Yanchep National Park under the planned abstraction reductions – not enough to meet existing Ministerial criteria. Changes to local abstraction e.g. within the Park itself may be able to improve water level outcomes further than current modelling projects, and will more further investigation within the life of the plan. It may be possible to achieve a higher threshold as a result.  **Details of proposed change to Ministerial criteria:** Adopt the 2013 minimum level at Lake Yonderup of 5.6 mAHD as a trigger level for the review of public water supply abstraction reduction by 2024. Beyond 2028, adopt a threshold level of 5.7 mAHD (0.2 m lower than the existing criterion). |
| Lake Joondalup | *1b) Maintain health*  Maintain groundwater levels to:   * maintain permanent water for fauna habitat and for visual amenity * maintain diverse aquatic plants and fringing vegetation * minimise risk of acidification. | 6162572 (staff 8281)  [61610661 (bore 8281) | 15.8 | 16.2 | Monitoring shows that managing levels to the existing minimum criterion will not meet the site management objectives, and the criterion should be raised to reduce risk of acidification. Current levels are above the proposed threshold and modelling projects the threshold level will continue be met beyond 2030.  **Details of proposed change to Ministerial criteria:** Beyond 2028, adopt a threshold level equal to the current preferred minimum criterion of 16.2 mAHD. |
| Lake Mariginiup | *1b) Improve health*  Improve groundwater levels to:   * increase wading bird habitat * maintain rich aquatic macroinvertebrate community * reduce lake acidity to beneficial levels for fauna. | 6162577 (staff 1943)  61610685 (bore MS10) | 41.5 (minimum peak) | 42.1 | Water levels are currently below the existing minimum peak criterion but modelling projects levels will rise at Lake Mariginiup as a result of land use change and associated reductions in local abstraction. These rises mean that meeting the existing preferred minimum peak will be achievable at 2030.  **Details of proposed change to Ministerial criteria:** Beyond 2028, adopt a threshold level equal to the existing preferred minimum peak of 42.1 mAHD. |
| Lake Jandabup | *1b) Improve health*  Improve groundwater levels to:   * increase wading bird habitat * maintain rich aquatic macroinvertebrate community * minimise risk of acidification. | 6162578 (staff 1944) | 44.2  (minimum peak) |  | Lake Jandabup is artificially maintained by the Water Corporation. Water levels are currently below the existing absolute minimum criterion but modelling projects levels will rise as a result of land use change and associated reductions in local abstraction to the extent that artificial maintenance may no longer be required within the plan period.  **Details of proposed change to Ministerial criteria:** Remove absolute minimum peak criteria as this is too low to meet water quality objectives of minimising risk of acidification. Retain current absolute minimum Ministerial criteria of 44.3 mAHD as the 2030 threshold. |
| 6162578 (staff 1944) | 44.3 | 44.3 |
| Lake Nowergup | *1b) Improve health*  Improve groundwater levels to:   * increase area of permanent deep water habitat for fauna * maintain fringing vegetation to support macroinvertebrate diversity and nutrient retention. | 6162567 (staff 8756) for Ministerial criteria | 16.8 (minimum peak) | 16.0 | Ministerial criteria are applied at staff gauge, proposed threshold levels will apply at PM33. Corresponding threshold level at staff gauge to be confirmed. Lake Nowergup is artificially maintained by the department.  Modelling projects levels will rise at Lake Nowergup but the increase will not be enough to meet existing Ministerial criteria, even with continued artificial maintenance by the department.  **Details of proposed change to Ministerial criteria:** Beyond 2028, once the abstraction reductions have been implemented, adopt a threshold level of 18.0 mAHD.  Based on the relationship between past water levels, achieving a minimum level of 18.0 mAHD at PM33 should give a lake level threshold of 16.0 mAHD (0.8 m below the existing criterion). |
| 61610601 (bore PM33) for threshold  [616145 (telemetry site) additional monitoring site] |  | 18.0 |
| Lake Wilgarup | *1b) Improve health*  Improve groundwater levels to maintain soil moisture and minimise risk of acidification. | 61618500 (Wilgarup Lake bore) | 4.5 | 3.9 | Modelling projects small increases in groundwater levels are possible in Yanchep National Park under the planned reductions in abstraction. This will reduce risks to existing wetland values but will not be enough to meet the existing Ministerial criterion.  **Details of proposed change to Ministerial criteria:** Beyond 2028, adopt a threshold level of 3.9 mAHD (0.6 m lower than the existing criterion) at Wilgarup Lake bore. |
| Pipidinny Swamp | *1b) Improve health*  Improve groundwater levels to:   * increase area of permanent deep water habitat for fauna * maintain fringing vegetation to support a range of habitat types for macroinvertebrates. | 6162624 (staff)  61611872 (bore PIP\_C) | 1.6 | 1.1 | Modelling projects small increases in groundwater levels are possible in Yanchep National Park under the planned reductions in abstraction. This will reduce risks to existing wetland values but will not be enough to meet existing Ministerial criteria.  **Details of proposed changes to Ministerial criteria:** Beyond 2028, adopt a threshold level of 1.1 mAHD (0.5 m lower than the existing criterion) at bore PIP\_C. |
| Lexia 186\* | *1b) Maintain health*  Maintain fringing and wetland vegetation to support a range of habitat types. | 61613214 (bore GNM15) | 47.2 | 46.5 | Modelling projects the planned reductions in abstraction can maintain water levels at Lexia 186 but that the existing Ministerial criterion cannot be achieved.  **Details of proposed changes to Ministerial criteria:** Adopt the 2013 minimum level of 46.5 mAHD as the threshold level (0.7 m lower than the existing criterion). |
| Melaleuca Park 173 | *2) Manage declines in groundwater levels to reduce risk to ecological health*  Limit declines in health of fringing and wetland vegetation to support a range of habitat types. | 61613213 (bore GNM14)  [6162628 (staff) additional monitoring site] (bore) | 50.2 | 48.5 | Modelling projects the planned reductions in abstraction will reduce but not fully arrest further water level declines at Melaleuca Park 173, and ecological values associated with the presence of surface water, such as macroinvertebrate, frog and fish species, may eventually be lost.  **Details of proposed changes to Ministerial criteria:** Beyond 2028, adopt a threshold level at bore GNM14 of 48.5 mAHD (1.7 m lower than the existing criterion).  Given the water level declines associated with this threshold level, which is based on modelled projections in a dry climate scenario, could result in significant impacts to ecological values, management options to improve water level outcomes and a achieve a higher threshold level will be further investigated within the life of the plan. |
| Melaleuca Park 78 | *2) Manage declines in Superficial groundwater levels to reduce risk to ecological health*  Limit declines in health of wetland vegetation. | 61613231 (bore GNM31) | 65.1 | 64.7 | Modelling projects the planned reductions in abstraction will reduce but not fully arrest further water level declines at Melaleuca Park 78, most likely leading to progressive encroachment of dryland vegetation species into the wetland.  **Details of proposed changes to Ministerial criteria:** Beyond 2028, adopt a threshold at bore GNM31 of 64.7 mAHD (0.4 m lower than the existing criterion). |
| MM59B Whiteman Park East | *1b) Improve health*  Improve groundwater levels to improve the condition of dependent vegetation and potential Banksia woodland threatened community. | 61611025 (bore MM59B) | 36.3 | 36.2 | Modelling projects water levels will rise in this area as a result of the planned reductions to abstraction, but that the rises will not be sufficient to meet the current Ministerial criteria.  **Details of proposed changes to Ministerial criteria:** Beyond 2028, adopt a threshold level at bore MM59B of 36.2 mAHD (0.1 m below the existing criterion). |
| PM9 Pinjar North |  | 61610804 (bore PM9) | 56.3 | - | Groundwater levels have dropped to greater than 10m below ground surface and vegetation at PM9 is considered no longer groundwater-dependent.  Model results indicate the proposed reductions in abstraction will not arrest further water level declines at PM9. The department is proposing to remove PM9 as a criteria site. |
| WM1 Pinjar | *2) Manage declines in Superficial groundwater levels to reduce risk to ecological health*  To avoid significant impacts to the habitat values of the Banksia woodland community as it transitions from groundwater-dependent to non-groundwater dependent vegetation. | 61610833 (bore WM1) | 55.7 | 53.7 | Modelling projects the planned reductions in abstraction will reduce but not fully arrest further water level declines at WM1.  **Details of proposed changes to Ministerial criteria:** Beyond 2028, adopt a threshold at bore WM1 of 53.7 mAHD (2.0 m below the existing criterion).  Given the water level declines associated with this threshold level, which is based on modelled projections in a dry climate scenario, could result in significant impacts to Banksia woodland community, management options to improve water level outcomes and a achieve a higher threshold level will be further investigated within the life of the plan. |
| WM2 Melaleuca Park North | *2) Manage declines in Superficial groundwater levels to reduce risk to ecological health*  To avoid significant impacts to the habitat values of the Banksia woodland community as it transitions from groundwater-dependent to non-groundwater dependent vegetation. | 61610908 (bore WM2) | 66.5 | 64.7 | Modelling projects the planned reductions in abstraction will be able to reduce but not fully arrest further water level declines at WM2.  **Details of proposed changes to Ministerial criteria:** Beyond 2028, adopt a threshold at bore WM2 of 64.7 mAHD (1.8 m below the existing criterion).  Given the water level declines associated with this threshold level, which is based on modelled projections in a dry climate scenario, could result in significant impacts to Banksia woodland community, management options to improve water level outcomes and a achieve a higher threshold level will be further investigated within the life of the plan. |
| WM8 Melaleuca Park | *2) Manage declines in Superficial groundwater levels to reduce risk to ecological health*  To avoid significant impacts to the habitat values of the Banksia woodland community as it transitions from groundwater-dependent to non- groundwater dependent vegetation. | 61610983 (bore WM8) | 64.8 | 63.7 | Modelling projects the planned reductions in abstraction will be able to reduce but not fully arrest further water level declines at WM8.  **Details of proposed changes to Ministerial criteria:** Beyond 2028, adopt a threshold at bore WM8 of 63.7 mAHD (1.1 m below the existing criterion).  Given the water level declines associated with this threshold level, which is based on modelled projections in a dry climate scenario, could result in significant impacts to Banksia woodland community, management options to improve water level outcomes and a achieve a higher threshold level will be further investigated within the life of the plan. |
| Lake Gwelup | *1b) Maintain health*  To maintain permanent water for fauna habitat and for visual amenity, to maintain fringing vegetation. | 61610032 (bore 8525)  6162504 (staff 465) |  |  | Proposed new site. Water level trigger and threshold to be proposed to the EPA in 2019. |
| Quin Brook | To be proposed in the Gingin water allocation plan (draft expected in 2023). | 61710060 (bore GC11) \*interim site |  |  | Proposed new site. Threshold to be proposed in the draft Gingin water allocation plan. |
| Gingin Brook | To be proposed in the Gingin water allocation plan (draft expected in 2023). | 61710078 (bore GB13) \*interim site |  |  | Proposed new site. Threshold to be proposed in the draft Gingin water allocation plan. |

Table 3: Wetlands with Ministerial criteria affected by future land use changes in East Wanneroo.

| **Site name** | **Maximum water level**  **(WAWA,1995)** | **Bore or staff gauge where water level threshold is measured** | **Projected (modelled) water level increase to 2030, in vicinity of wetland (from 2013 levels)** |
| --- | --- | --- | --- |
| Lake Goollelal | * 27.5m AHD * Breach permitted for a maximum of two consecutive years, and for no greater than two years in six | 6162517  (staff 459) | 0.4 m |
| Lake Joondalup | * 17.6m AHD * Breach permitted for a maximum of two consecutive years, and for no greater than two years in six | 6162572  (staff 8281) | 2.1 m |
| Lake Mariginiup | * 42.6m AHD   Breach permitted for a maximum of two consecutive years, and for no greater than two years in six | 6162577  (staff 1943) | 3.9 m |
| Lake Jandabup | * 46.1m AHD * Breach permitted for a maximum of two consecutive years, and for no greater than two years in six | 6162578  (staff 1944) | 3.4 m |